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FEATURE

SCE Refrigerated Display Case Efficiency Initiative

Dan Greenberg

What would you do if you found a hole in your refrigerator door that was responsible for 80 percent of the appliance's cooling load? You'd probably fix it or replace it in short order. Well, surprising as it may sound, there are huge numbers of such refrigerators operating throughout the world today, and nobody's doing a thing about them. Well, almost nobody, that is.

These refrigerators are the open vertical display cases found in most supermarkets and grocery stores, displaying everything from albacore tuna to zucchini. The gaping hole that gives consumers unfettered access to the goods makes these display cases notoriously inefficient at keeping products cold, but energy efficiency is of minimal importance to stores compared with the primary function of the cases—displaying and moving product.

Although display-case manufacturers have taken numerous steps in recent years to improve the energy efficiency of their products (offering higher-efficiency evaporator fan motors, high-efficiency lighting, and better insulation), no one has yet tackled the 900-pound gorilla that limits the efficiency of every open vertical display case—the simple fact that the cases are *open*. Studies have shown that simply placing doors on these cases would reduce their energy consumption by about 60 percent,[1] but that would be unacceptable to supermarket merchandisers, who fear that inserting any barrier between the consumer and the product would cause a decline in sales. The second-best option is to improve the function of the air curtain that creates a relatively ineffective thermal barrier between the refrigerated interior of the display case and the outside world. This is the quest of Ramin Faramarzi, manager of the Refrigeration and Thermal Test Center (RTTC) at Southern California Edison (SCE).

Inside ET

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RETROSPECTIVE

Whatever Happened to Smart Windows?

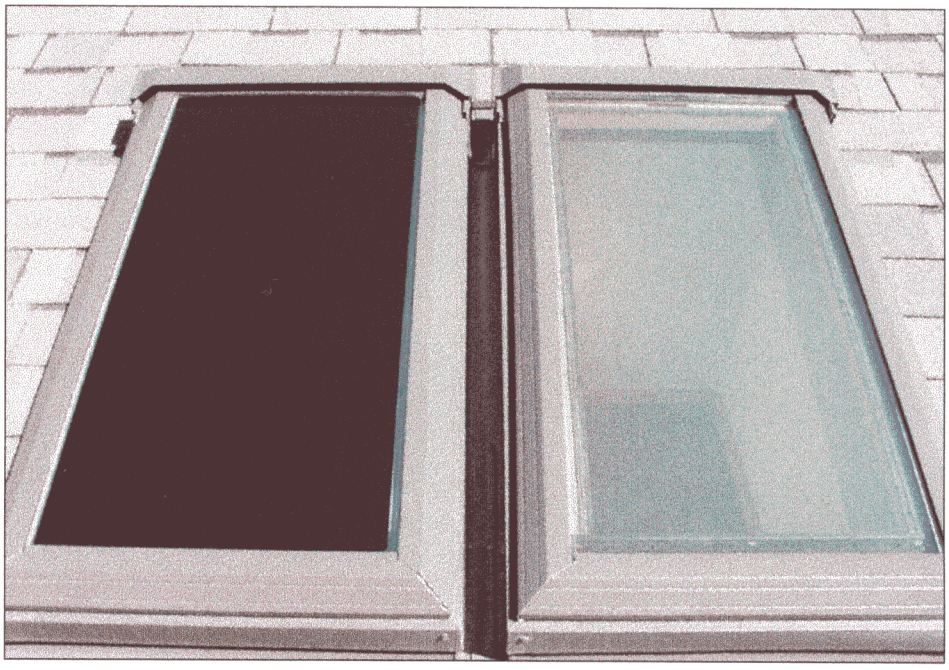
Kristi Kamm

The big news today in smart windows is that you can actually buy them for the first time. Two companies that we profiled in a previous article ("Electrochromics: Now You See It; Now You Don't," *E SOURCE Emerging Technology Currents*, no. 4, November 2000) have introduced high-end products for both commercial and residential buildings. A smart window looks like a conventional window but users are able to "tune" it by turning a dial or by using an automated lighting control system. Either action results in voltage variations that change the tint of the window from clear (or light blue) to dark blue, or anywhere in between, in response to the weather conditions or user preferences (**Figure 5**).[10]

In our previous article, we called smart windows a "revolutionary development in fenestration" because of their controllability. The windows can conserve energy used for heating and cooling by accepting more solar gain (heat from the sun) in the winter than in the summer (**Table 1**, page 11).[11] They can also minimize lighting energy consumption by allowing daylight in or can reduce glare by keeping daylight out. Eleanor Lee, a scientist at Lawrence Berkeley National Laboratory (LBNL), says that simulations of buildings with dimmable lighting systems shows that, compared with spectrally selective low-e windows, smart windows using electrochromic technology can reduce

Figure 5: A VELUX skylight in light and dark states

These 5.3-square-foot skylights use technology developed by SAGE Electrochromics to switch from light to dark or anywhere in between.



Courtesy: Sage Electrochromics Inc. [10]

total annual energy use in a building's perimeter zone by up to 30 percent.[12] And they can accomplish all of these feats while consuming very little energy.

Just the Two of Us

Two small companies, each formed solely to pursue smart window technology, have introduced products:

- *SAGE Electrochromics Inc.* At the end of 2002, after 12 years of development, SAGE's retailers introduced the company's technology for commercial and residential windows for the building supply market. SAGE applies a tint-controllable electrochromic coating to glass, which is then sold to window and skylight manufacturers to be made into finished products. SAGE's technology has passed independent durability testing conducted by the DOE.

- *Research Frontiers Inc.* For the past 40 years, researchers at Research Frontiers have been working on smart window technology. Retailers were finally able to introduce the company's technology to the residential and commercial window market in early 2004. Research Frontiers does not do any manufacturing itself; it licenses its suspended-particle technology to companies that produce a switchable window film that is different at the molecular level from SAGE's technology. Those companies send the film to window manufacturers, which laminate it to glass and finish the product.

Both SAGE and Research Frontiers are promising improved product performance within the next two years. For example, Research Frontiers is working to admit more light through the window when it's in the high-transmission state by raising the visible light transmission level from 25 to about 60 or 70 percent.[13]

Meanwhile, Thomas Richardson, staff scientist at LBNL, is aiming to up the ante with an altogether new technology. He is developing a window coating that adjusts from clear to reflective, instead of clear to tinted. This approach could result in much less solar heat gain while admitting the same amount of daylight, which could further reduce energy use in buildings.

If You've Got the Money, Honey

In the opinion of Roland Pitts, a scientist at the National Renewable Energy Laboratory, cost and market entry are the biggest issues for smart windows right now.[14] Product costs are very high because the products are basically hand-crafted, due to the small quantities that are currently being manufactured. An untinted skylight with a motorized open/close function and a rain sensor offered by VELUX costs $400, but customers would have to spend $1,800 (or $340/ft^2) for one made with SAGE glass. Michael Myser, SAGE's marketing

Table 1: Attributes of smart windows

Smart windows can achieve a very dark tint and restrict the transmission of visible light, but they cannot become as clear as plain glass, which transmits 85 percent of visible light. Solar heat gain can be as low as 13 percent in the dark-tinted state for windows using SAGE Electrochromics' technology, but only 30 percent for windows using Research Frontiers' technology. Therefore, the SAGE product can more effectively minimize a building's cooling energy requirement. The warranty offered for products made with SAGE technology matches those offered for conventional windows—typically 10 or 20 years. Data has been provided by the technology developer except where noted.

	Research Frontiers	SAGE Electrochromics
Visible light transmittance	1 to 25 percent for a triple-paned window from SPD Technologies[a]	4 to 59 percent for a double-paned skylight from VELUX
Solar heat gain	30 to 43 percent for a triple-paned window from SPD Technologies	13 to 43 percent for a double-paned skylight from VELUX
Maximum power requirement	0.05 watts per square foot required to maintain the high-transmission state	0.2 watts per square foot required when switching
Switching speed	1 to 3 seconds; does not depend on glass size	1.5 to 3.0 minutes for a 5.3-square-foot VELUX skylight[b]
Length of warranty	5 years for a ThermoView residential window	10 years for a VELUX skylight

Notes: a. Data from Architectural Testing Inc., provided by SPD Technologies Inc., Smyrna, DE, www.infinitint.com.
b. Data from customer service at VELUX, Greenwood, SC, 800-888-3589, www.velux-america.com.

Source: Platts; information from SAGE Electrochromics and Research Frontiers [11]

director, says the company is targeting a premium of less than $100 with increased production levels.[15] Charles Smith, CEO of window retailer Thermoview, claims that his company's products made with Research Frontier's technology generally cost about 80 percent more than the company's best-quality conventional replacement windows.[16] Thermoview quoted us a retail price of $245/ft^2 for an 8-ft^2 window.

Commercialization should help lower costs by increasing the volume of manufactured product and paving the way for the implementation of mass production. But even with increased production, this will be no slam-dunk. Inexpensive, widely used low-e coatings consist of a series of thin and easy-to-deposit layers, whereas smart windows are composed of thicker and more-complex layers. That will likely make driving down the cost of smart windows a slower, more-difficult process. In addition, there's the cost of wiring and control equipment. We expect that eventually, with increased manufacturing volume, technological improvements in the coating process, and the addition of innovative new materials for coatings, prices will come down, but research and market challenges remain.

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Notes

1 Ramin Faramarzi (April 27, 2004), Manager, Southern California Edison Refrigeration and Thermal Test Center, Irwindale, CA, 626-633-7168, ramin.faramarzi@sce.com.

2 Paul Komor, Clay Fong, and Joanna Nelson, "Delivering Energy Services to Supermarkets and Grocery Stores," *E SOURCE Multi-Client Study* (1998), p. 21.

3 Food Marketing Institute, "Supermarket Operating Costs 2002" (June 2003), from www.fmi.org/facts_figs/keyfacts/super.htm (accessed May 4, 2004).

4 Steve Nadel (May 6, 2004), Executive Director, American Council for an Energy Efficient Economy, Washington, DC, 202-429-8873, snadel@aceee.org.

5 Ramin Faramarzi (May 27, 2004) [1].

6 Ramin Faramarzi (May 27, 2004) [1].

7 Ramin Faramarzi, Rafik Sarhadian, Bruce Coburn, Scott Mitchell, and John Lutton, "Analysis of Energy Enhancing Measures in Supermarket Display Cases," presentation at the ASHRAE 2004 Annual Meeting, Anaheim, CA (January 26, 2004).

8 John Doty (May 19, 2004), Manager, Corporate Communications, IdleAire Technologies Inc., Knoxville, TN, 865-342-3600, jdoty@idleaire.com.

9 Fiberstars Inc. press kit, handed out at LightFair International 2004, Las Vegas, NV (March 31, 2004).

10 Julie Van Dine (May 26, 2004), Creative Director, SAGE Electrochromics Inc., Faribault, MN, 507-333-0078, julie@sage-ec.com.

11 Michael Myser (April 30, 2004), Vice President, Sales and Marketing, SAGE Electrochromics Inc., Faribault, MN, 507-333-0078, mmyser@sage-ec.com; and Michael LaPointe (April 30, 2004), Vice President, Marketing, Research Frontiers Inc., Woodbury, NY, 800-743-4453, lapointe@smartglass.com.

12 Eleanor Lee (March 5, 2004), Scientist, Lawrence Berkeley National Laboratory, Berkeley, CA, 510-486-4997, eslee@lbl.gov.

13 Michael LaPointe [11].

14 Roland Pitts (April 28, 2004), Optoelectronics Team Leader, National Renewable Energy Laboratory, Golden, CO, 303-384-6485, roland_pitts@nrel.gov.

15 Mike Hughlet, "Window on the Future," *Saint Paul Pioneer Press* (February 15, 2004), p. 8D.

16 "Smart Windows," *NEC Digest* (July 15, 2002), from www.nfpa.org/nec/Resources/IndustryNews/SmartWindows/SmartWindows.asp (accessed May 25, 2004).